J. Soils and Crops 32 (1) 64-70, June 2022

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

EFFECT OF DIFFERENT APPLICATION METHODS OF NITROGEN AT SEEDLING STAGE AND DIFFERENT TOP DRESSING METHODS ON YIELD OF RICE (*Oryza sativa* L.)

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ABSTRACT

Field experiment to determine "Effect of different application methods of nitrogen at seedling stage and different top dressing methods on yield of rice" was conducted at the Research Farm of College of Agriculture, Central Agricultural University, Imphal, Manipur during the *kharif* season of 2018. The experiment consisted of three different methods of nitrogen fertilizer application at seedling stage i.e. soil application, root dipping and foliar spray and three different top dressing methods of nitrogen i.e. broadcasting, mudball placement and pellet placement. The results revealed that among different methods of nitrogen application at seedling stage, foliar spray was the most effective method in yielding highest grain yield (5.21 t ha^{-1}) and yield attributing characters such as panicle length (27.19 cm), number of effective tillers m^2 (166.27), lowest sterile spikelets (26.25%), number of filled grains panicle^{-1} (146.88). Similarly root dipping method recorded highest straw yield (7.84 t ha^{-1}) with high number of effective tillers m^2 (177.10). Among the different top dressing methods mudball placement was the most effective method, which recorded highest grain yield (5.35 t ha^{-1}) and all other yield attributing characters apart from a non-significant number of filled grains panicle^{-1}. However, it was also evident that the combined effect of foliar spray with mudball placement recorded higher grain yield (6.42 t ha $^{-1}$), harvest index (52.06%) and yield attributing characters such as panicle length (30.13cm), effective tillers m^2 (205.09), number of filled grains panicle^{-1} (160) and significantly lowest percentage of sterile spikelets (22.25%).

(Key words: Soil application, foliar spray, root dipping, top dressing, mudball placement, pellet placement, yield)

INTRODUCTION

Rice is possibly the oldest domesticated grain (10000 years) and is central to billions of people around the world. It is also staple food for 2.5 billion people and provides 15 % of capital protein and 21% of global human capita^{-1} energy. Rice fields covers more than 125 million ha land which is roughly 9% of entire earth's arable land. Proper research in the crop has led to doubling world's rice production from 260 million tons to 600 million tonnes. (Maclean *et al*., 2002). Nitrogen is a key nutrient for rice production and is required in large quantity. It is the most limiting nutrient in production of rice, further when it is applied as inorganic sources in puddled field condition it has heavy system losses (Fillery *et al.,* 1984). The utilization of conventionally broadcasted N fertilizers in rice is inefficient. Mitsui (1954) estimated that rice recovers only 30-40% of applied fertilizer N, whereas upland crops recover 50- 60%. The remaining 60- 70% of the N applied to rice is subject to gaseous losses through ammonia volatilization and nitrification-denitrification or to losses in water through leaching and runoff. (Broadbent 1978, 1979, Patnaik and Rao, 1979). Available nitrogen in the soil is highest at maximum tillering stage and significantly reduced at panicle initiation stage indicating a higher requirement by crop

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during vegetative growth stage (Tamuly and Bastin, 2019). There are many attempts to improve the efficiency of ammonical fertilizers for lowland rice which include deep placement of urea as mudballs placed in reduced layers of paddy soil. It is an ideal method of fertilizer application which should hold nitrogen in a form that should not be lost through denitrification and ammonia volatilization, which would usually occur when nitrogen is applied to floodwater or as surface application. Field trails at IRRI recorded higher grain yield by use of mudball. (Anonymous, 1974a, Anonymous 1975b, Shiga *et al*., 1977). Urea can also be supplied to plants through the foliage, which facilitates optimal growth and proper nitrogen management, further minimizing nitrogen losses to the environment without affecting yield (Millard and Robinson, 1990). Foliar spray of fertilizer not only reduces the quantity of fertilizer applied through soil but also helps in increasing crop yields. It also reduces lag time between fertilizer application and fertilizer uptake (Ahmad and Jabeen, 2005). Root dipping as a fertilizer application method at seedling stage has mostly been used in micronutrients application such as zinc, boron etc. (Khan *et al.*, 2003).

MATERIALS AND METHODS

The present investigation was conducted at Research farm, College of Agriculture, Central Agricultural University, Imphal (Manipur) during *kharif* season of 2018. The experimental site is located at 24.45^0 N latitude and 93.56^0 E longitudes with an elevation of 790 Meters above mean sea level. The experiment was laid out in Factorial randomised block design (FRBD) with 9 treatments and 3 replications. Treatments consisted of 3 methods of nitrogen application at seedling stage i.e. soil application, root dipping and foliar spray with three nitrogen top dressing methods i.e. broadcasting, mudball placement and pellet placement at main field. Seedling nursery was laid out in three sub plots consisting of soil application, root dipping and foliar spray. Basal dose of required P and K were supplied through SSP and MOP respectively. N was supplied only in soil application sub plot as per the treatment. Later foliar spray was done @ 2% urea in one of sub plot and finally root dipping was done in one of sub plot as per the treatment @ 2% urea solution for 24 hrs before transplanting. The main field for transplanting was prepared and divided into 27 plots where equal doses of NPK: 60-40-30 kg ha^{-1} was applied, of which P_2O_5 @ 40 kg ha^{-1} and K_2O @ 30 kg ha^{-1} was commonly applied to all the plots, whereas nitrogen was applied in split doses at active tillering and panicle initiation stage. Mudball urea and pellet urea were prepared by procedure provided by (Chandraserkaran *et al.,* 2008), where mudballs were made 1 cm in diameter and a hole was made in centre of ball and urea was inserted in it and the hole was closed then was applied 10-12 cm deep in the root zone of crop with one mudball between every 4 rice hills. CAU- R1 seedlings were transplanted at spacing of 20 cm × 20 cm with two seedlings $hill^{-1}$ in 10 m^2 plot. The mudball with fertilizer, weighed 30 g and contained 209 mg urea $ball^{-1}$ was applied @ 1 mudball in centre of 4 hills of rice 10-12 cm deep at active tillering and panicle initiation stage. Broadcasting of urea was done @ 130 g $plot^{-1}$ at tillering and panicle initiation stage. Observations on panicle length, number of filled grains $panicle^{-1}$, test weight, spikelet sterility, grain yield, straw yield and harvest index were recorded after harvest and number of effective tillers was recorded at 90 DAT. The treatment means were compared using least significant difference at 5% level of significance. Microsoft Excel was used for tabulation and simple calculation, presentation of table for different comparisons (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Panicle length

The length of panicle was significantly affected by different methods of nitrogen application at seedling stages. Foliar spray at seedlings stage (27.19 cm) recorded significantly longer panicles over root dipping (24.88 cm) and were similar with soil application (26.24 cm). This may be due to enhanced rate of photosynthesis which contributed to formation of longer panicles, later on the plant growth due to foliar sprays of seedlings. Similar findings were also reported by Manik *et al.,* (2016) where they reported significantly longer panicle formation by the application of 50 % prilled urea + 5 foliar sprays @ 0.5% N solution @ 5.5 kg N $spary^{-1}$ (23.80 cm) over soil application of nitrogen alone.

Panicle length was also significantly affected by different top dressing methods. Mudball placement (27.36 cm) significantly recorded longer panicles over pellet placement (25.08 cm) and were at par with broadcasting (25.08 cm). This may be due to fact that urea applied in mudballs releases nitrogen slowly which ensures sufficient N at panicle formation stage which in turn helps in obtaining better results. The finding was being in conformity with (Hasanuzzaman *et al.*, 2009), who reported that deep placement of Urea super granules @ 75 kg^{-1} recorded statically superior panicle (22.3 cm) over split broadcasted applications and foliar sprays treatments. Further, similar findings were also reported by (De Datta and Lee, 1976), where they reported longer panicle formation in mudball applied rice fields (23.1 cm) over other application methods such as split soil broadcastings and control.

The interaction of foliar spray with mudball placement recorded longest panicle length (30.14 cm) which were at par with interaction of soil application with broadcasting (27.08 cm) and were significantly higher than all other treatment interactions. Lowest panicle length was recorded by treatment interaction of root dipping with broadcasting (23.73cm). Further all other remaining interactions were at par with each other.

Number of filled grains $panicle^{-1}$

Different methods of nitrogen application at

seedling stage had a positive significant effect on number of filled grains panicle^{-1}. Seedlings treated with foliar spray (146.89) recorded highest number of filled grains panicle^{-1} over soil application method (125.56). Root dipping method (134.44) was at par with foliar spray (146.89). This may be due to the fact that application of macronutrients through foliage may have improved the photosynthetic ability of crop thereby more food material synthesized contributed to the improvement of more number of filled grains panicle^{-1}. Bhuyan *et al.* (2015) also reported similar results, where they found out that foliar application in bed planting method yielded 128 filled grains panicle^{-1} which was significantly higher than fertilizer broadcasted in conventional planting method (106).

Whereas, top dressing method differed insignificantly. However, highest filled grains panicle^{-1} was recorded by mudball placement (139.67) over pellet placement (132.78). Better performance of mudball placement might be due to higher uptake and higher recovery of nitrogen when applied at panicle initiation stage. Further the coincidence of grain formation and fertilizer application coupled with reduced losses of nitrogen at times of peak crop growth might have led to formation of good number of filled grains panicle^{-1}.

Different treatment interactions highlighted significant differences with respect to number of filled grains panicle^{-1} where highest number of filled grains panicle^{-1} was recorded by foliar spray with mudball placement (160) followed by broadcasting with foliar spray (150.67). The two treatment interactions were at par with each other. Lowest number of filled grains panicle^{-1} was recorded by the treatment interaction of soil application with broadcasting (117). Further all other remaining treatment interactions were at par with each other.

Test weight

There was no significant difference among different application methods of nitrogen application at seedling stage which may be due to the varietal inert property of the CAU-R1 variety. It is a well-known fact that test weight among a same variety does not differ significantly as reported by Alam *et al.* (2010) and Manik *et al.* (2016). However, highest test weight was recorded by root dipping method (26.19 g) followed by foliar spray (26.09 g) and the lowest test weight recorded by soil application (25.97 g).

There were also no significant differences among different top dressing methods of nitrogen fertilizer application for test weight, where similar findings were reported by Aktar *et al.* (2018). Their findings also stressed the non-significant influence on test weight of a rice variety when subjected to different top dressing fertilizer application methods. However, highest test weight was recorded by mudball placement (26.21 g) followed by broadcasting (26.20 g) and finally pellet placement recorded lowest test weight (25.85 g)

The interaction of treatments also did not differ significantly. However, foliar spray with mudball placement recorded highest test weight (26.54g) followed by the interaction of root dipping with pellet placement (26.34g) and finally the interaction of soil application with pellet placement (25.59) recorded lowest test weight.

Number of effective tillers m^{-2}

The results of different methods of nitrogen application at seedling stage had a significant outcome on the number of effective tillers m^{-2}, where root dipping of seedlings in (2%) urea solution recorded highest number of effective tillers m^{-2} (177.10) over soil application (145.04). Foliar spray (166.27) was at par with root dipping (177.10) method. Root dipping exhibited better absorption of nitrogen fertilizer when incubated for 24 hrs. before transplanting which led to development of robust root system. Similar findings were reported by Thakuria and Singh (2018), where they reported more number of effective tillers formation due to dipping of rice seedlings in solution of SPP soil slurry+PSB+RB over SSP broadcast alone and control.

Different top dressing methods also differed significantly where, mudball placement (179.70) recorded highest number of effective tillers m^{-2}, while broadcasting (151.88) recorded lowest number of effective tillers m^{-2}. Broadcasting (151.88) and pellet placement (156.83) methods were at par with each other. It can be noted that efficiency of deeply placed mud balls which provide steady release of nitrogen to plant roots for a long time at critical period of crop growth may have led to formation of more number of effective tillers m^{-2}. Similar findings were reported by Lawal *et al.* (2003), where they found that deep placement of mudballs yielded significantly more number of ear bearing tillers m^{-2} over surface application method over three seasons which were 440.73, 603.69 and 501.01 for deep placement which were significantly higher than 393.65,491.54 and 427.02 respectively for surface application method over three seasons.

The interaction of foliar spray with mudball placement recorded highest number of effective tillers m^{-2} (205.09) followed by the interaction of root dipping with mudball placement (190.33). Finally, the interaction of foliar spray with pellet placement recorded lowest number of effective tillers m^{-2} (138.65). Further all other treatments interaction was at par with each other.

Spikelet sterility

The results for spikelet sterility reveals a significantly higher sterile spikelet in root dipping (31.64%) of seedling over foliar spray (26.25%), who recorded lower sterile spikelets. Soil application (27.73%) was found to be at par with foliar spray method (26.25%). More number of filled grains formed due to foliar spray in rice over other application methods may be the reason that foliar spray of seedlings recorded lower spikelet sterility. These results were on conformity with Bhuyan *et al.* (2012), where they found that foliar spray on bed planting had a reduced spikelet sterility of (9.28%) over broadcasted method in conventional planting (12.41%). Further the study of Bhuyan *et al.* (2015) also found that foliar spray had a significantly lower sterility

of (13.12%) over fertilizer broadcasting method (16.21%).

The results of spikelet sterility in different top dressing methods in main field also highlighted a significant higher sterile spikelets in pellet placement (30.17%) over broadcasting (29.42%) and mudball placement (26.03%). However, broadcasting (29.42%) method was found to be at par with pellet placement method. Broadcasting method had a high sterile spikelets over mudball placement which may be due to the reason that application of heavy nitrogen increases tillering as well as spikelet sterility plant^{-1} which in turn reduces the number of engorged pollen grains anther^{-1} and leading to increase spikelet sterility. The results of Ullah *et al*., (2016). highlighted that deep placement of Urea super granule @ 66 kg ha^{-1} significantly reduced total spikelet sterility which were USG (5%), no nitrogen (14.9%), Prilled Urea (10.3%) and NPK mix (9.6%) respectively.

The interaction of broadcasting and root dipping (35.13%) recorded significantly highest sterile spikelets followed by the interaction of root dipping and mudball placement (31.31%) and the interaction of mudball placement with foliar spray (22.25%) recorded significantly lowest sterile spikelets.

Grain yield

The results revealed a significant impact of fertilizer application methods at seedling stage on yield of rice plants. Foliar spray of seedlings (5.21 t ha^{-1}) recorded significantly higher yield over soil application (4.52 t ha^{-1}). Application methods root dipping (5.13 t ha^{-1}) and foliar spray (5.21 t ha^{-1}) were at par with each other. This yield increase trend was similarly being reported by Bhuyan *et al*. (2012), where they reported a yield increase of 9.33% by foliar application method over conventional application method of fertilizer. The findings of Jagatjothi *et al.* (2012) also supported the notion of improving grain by foliar spray of urea where, application of 2% Urea phosphate sprayed at panicle initiation and 10 days later recorded significantly highest grain yield (5631 kg ha^{-1}) over RDF top dressing (4419 kg ha^{-1}). Pise *et al.* (2019) also highlighted the significance of soil application of RDF and foliar application of nutrients in lathyrus, where grain yield (1.35 t ha^{-1}) was significantly increased and was highest in treatment soil application of RDF and foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5%).

Similarly, different top dressing methods also differed significantly where, mudball placement (5.35 t ha^{-1}) had a better grain yield performance over broadcasting (4.98 t ha^{-1}) and pellet placement (4.53 t ha^{-1}) methods. The methods broadcasting (4.98 t ha^{-1}) and pellet placement (4.53 t ha^{-1}) were at par with each other. It can be noted that mudball placement leads to increase applied nitrogen recovery (73.2%) compared to incorporation (51.6%) and top dressing (59.5%) as highlighted by (Shiga *et al*., 1977) which lead to formation of heavier filled grains thereby improving yield. Further, Simsiman *et al*., (1967) revealed that placement of 80 kg ha^{-1} N at 15 cm depth increased the plant N content at all stages of growth and significantly increased grain yield (7701 kg ha^{-1}) compared to broadcast and incorporation method. Ventura and Yoshida (1978) further reported a 10% increase in efficiency of ammonium fertilizer due to deep placement of ammoniated mudballs as compared to common practices of incorporation in puddled soil. They also noted that total N uptake to be higher (133.9 kg ha^{-1}) for deep placement of mudballs when compared (133.5 kg ha^{-1}) with top dressing. Kumar *et al.* (2019) also highlighted that application of 150% Recommended dose of NPK (180:60:60 kg ha^{-1} and Zn 25 kg ha^{-1}) recorded highest grain yield of 6.02 t ha^{-1} over control. Our study confirms to the fact that improvement of grain yield by deep placement of mudballs was due to higher nitrogen recovery, higher uptake of available nitrogen from mudballs, reduced losses, improved filled grains number and yield attributing characters which thereby improved the yield of crop.

The interaction of treatment combinations was also found to be significantly different, where significantly highest yield was recorded by treatment interaction of foliar spray with mudball placement (6.42 t ha^{-1}) followed by the interaction of root dipping with broadcasting (5.25 t ha^{-1}) and the lowest yield recorded by treatment interaction soil application with pellet placement (4.15 t ha^{-1}). All other treatments interaction was found to be at par with each other except for soil application with mudball placement (5.25 t ha^{-1}) and soil application with pellet placement (4.15 t ha^{-1}).

Straw yield

The results of the study revealed a significant impact on straw yield of the rice crop. Root dipping (7.84 t ha^{-1}) recorded significantly higher straw yield over foliar spray (6.21 t ha^{-1}) of seedlings. Methods foliar spray (6.21 t ha^{-1}) and soil application (6.75 t ha^{-1}) were at par with each other. The impact of root dipping producing highest straw yield may be due to fact that dipping of rice seedling before transplanting had played critical role in root growth and development at the early stage of crop growth which further helped in more vigorous uptake of nutrients by the roots and helped improvement in straw yield. Thakuria and Singh (2018) reported statistically similar straw yield of broadcasted SSP (3.38 t ha^{-1}) and root dipped SSP (3.08 t ha^{-1}).

The results of different top dressing methods also varied significantly with broadcasting (7.85 t ha^{-1}) having highest straw yield over mudball placement (6.15 t ha^{-1}) and pellet placement (6.97 t ha^{-1}). Mudball placement (6.15 t ha^{-1}) was at par with pellet placement (6.97 t ha^{-1}). Study conducted by Miah *et al.* (2017) revealed a similar result, where 220 kg urea applied as broadcasted top dressing alone recorded significantly higher straw yield (6.32 t ha^{-1}) over combined application as foliar spray and broadcasted top dressing (5.79 t ha^{-1}). The reason for the success of broadcasted treatment may be due to fact that soil applied urea tended to impact more of vegetative growth of transplanted rice and readily available which tended to produced more vegetative biomass over mudball and pellet placement. Further, Jondhale *et al. (*2021) reported similar

results, where the soil application of RDF+ $ZnSO_4.7H_2O$ @15 kg ha^{-1} at the time of transplanting recorded highest straw yield of 5.67 t ha^{-1} over other application methods.

The interaction of root dipping with broadcasting as top dressing method yielded significantly higher straw yield (9.39 t ha^{-1}) followed by the interaction of root dipping with pellet placement (8.22 t ha^{-1}) and the lowest straw yield was recorded by the interaction of foliar spray with mudball placement (5.65 t ha^{-1}).

Harvest index

Different methods of fertilizer application at seedling stage had a significant positive impact on harvest index of rice under study. Foliar spray (45.39 %) recorded significantly higher harvest index compared to soil application (40.13 %) and root dipping (40.09 %) methods. Application methods *viz*., soil application and root dipping were at par with each other. Improvement of harvest index is a result of higher economic yield of the crop which is contributed by better availability of nitrogen, increased photosynthetic ability rate and yield components of rice leading to high grain yield. Foliar spray of macronutrients might raise dry matter transformation from store parts to sink parts. Miah *et al.* (2017) reported similar observations, where application of 110 kg urea as top dressing + 33 kg N as foliar spray recorded highly significantly higher harvest index (49.10 %) over control of no urea (47.45%) and broadcasted top dressing of 220 kg urea (46.85%).

The effect of different methods of top dressing had a significant effect on harvest index. Mudball placement (46.03 %) as a top dressing method recorded highest harvest index over broadcasting (39.15 %) and pellet placement (40.44 %) methods. Higher harvest index is a result of better grain formation and higher grain yield combined with straw yield. Ahmed *et al*. (2018) found that deep placement of USG @ 75 kg ha^{-1} recorded a harvest index of 50.53% which was statically similar to LCC based application (50.70%) and split application of 220 kg ha^{-1} urea (49.51%).

The interaction of foliar spray with mudball placement (52.06 %) recorded significantly higher harvest index followed by the interaction of root dipping with mudball placement (46.66 %). The interaction of broadcasting with root dipping (35.81 %) recorded lowest harvest index.

The findings of the study revealed that foliar spray of rice at seedling stage helped in improvement in all the important yield attributing parameters of rice which were panicle length, spikelet sterility, number of filled grains $panicle^{-1}$, grain yield, harvest index excluding number of effective tillers m^{-2} and straw yield. Mudball placement of fertilizer when used as a top dressing method significantly recorded highest yield and yield attributing parameters except for straw yield, which might be due to slow release of nitrogen and their higher availability at peak growing stages of crop coupled with reduced losses. Further root dipping as seedling fertilization method helped in getting higher straw yield and more number of effective tillers m^{-2} and finally broadcasting as top dressing method recorded highest straw yield. However, the interaction of foliar spray at seedling stage and mudball placement as top dressing method can be used to enhance the yield of rice variety CAU-R1.

Table 1. Effect of different methods of nitrogen application at seedling stage and different top dressing method on yield and yield attributes of Rice variety CAU-R1

Treatments	Panicle length (cm)	Number of filled grains Panicle^{-1}	Test weight (g)	Number of effective tillers m^{-2}	Spikelet Sterility (%)	Grain yield t ha^{-1}	Straw yield t ha^{-1}	Harvest index (%)
Nitrogen application methods at seedling stage								
Soil application	26.24	125.55	25.97	145.04	27.72	4.52	6.75	40.13
Root dipping	24.88	134.44	26.19	177.10	31.63	5.13	7.84	40.09
Foliar spray	27.19	146.88	26.09	166.27	26.25	5.21	6.21	45.39
SE d (±)	0.85	6.24	0.25	9.29	1.45	0.26	0.41	1.56
CD(P=0.05)	1.82	13.24	-	19.70	3.07	0.56	0.87	3.32
Top dressing methods								
Broadcasting	25.86	134.44	26.20	151.88	29.41	4.98	7.85	39.14
Mudball placement	27.36	139.66	26.21	179.70	26.03	5.35	6.15	46.03
Pellet placement	25.08	132.77	25.85	156.82	30.16	4.53	6.97	40.44
SE d (±)	0.85	6.24	0.25	9.29	1.45	0.26	0.41	1.56
CD(P=0.05)	1.82	-	-	19.70	3.07	0.56	0.87	3.32
Interactions effect								
SE d (±)	1.48	10.82	0.43	16.09	2.50	0.46	0.71	2.71
CD(P=0.05)	3.15	22.93	-	34.12	5.31	0.97	1.52	5.75

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Rec. on 03.09.2021 & Acc. on 23.09.2021